Mariner Mars 1971 Launch Phase Study
Using the SFOF Mark IIIA Central Processing System Model

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Simulation models are currently being used for Space Flight Operations Facility (SFOF) development at the Jet Propulsion Laboratory. This report describes the results of three modeling runs made during April 1971 to evaluate the performance of the SFOF Mark IIIA Central Processing System, configured to support the launch phase of the Mariner Mars 1971 mission.

I. Introduction

Simulation models are currently being developed in the SFOF/GCF Development Section to support the design and implementation of the SFOF Mark IIIA Central Processing System (CPS).

SFOF Mark IIIA modeling studies began in May 1969 when it was learned that NASA would be providing JPL with IBM 360 Model 75 digital computers to form the nucleus of the SFOF Mark IIIA CPS.

The IBM computer system simulator (CSS) program was selected for model development activities since it runs on the 360/75 and the program itself applies specifically to computer systems.

The results of two modeling studies that were performed during the early stages of SFOF Mark IIIA development are described in Ref. 1.

This report describes the results of three modeling runs made during April 1971 to evaluate the performance of the SFOF Mark IIIA CPS, configured to support the launch phase of the *Mariner* Mars 1971 mission.

II. Mariner Mars 1971 Launch Phase Modeling Runs

A series of 10 runs was made using a model of the SFOF Mark IIIA CPS with *Mariner* Mars 1971 launch phase capabilities.

The primary objective of these system-level runs was to identify any apparent problem areas in the design of the hardware and software subsystems. Another objective was to determine the level of usage of available resources such as the central processing unit (CPU), core storage, and I/O devices.

The following events were simulated during the 10 runs:

(1) Processing and display of real-time tracking, telemetry and monitor data streams (one run).

(2) Real-time processing and the generation of tracking predicts (two runs).

(3) Real-time processing and the generation of sequence of events files (two runs).

(4) Real-time processing and the execution of the Command Generation program (COMGEN) (three runs).

(5) Real-time processing and the generation of tracking predicts and execution of COMGEN (two runs).

This report discusses the results of the three runs involving real-time processing and the execution of COMGEN.

III. Model Description

The model defined the hardware and software capabilities of the SFOF Mark IIIA CPS that will be required to support the launch phase of the *Mariner* Mars 1971 mission.

The IBM 360 Model 75J digital computer with one megabyte of main memory forms the nucleus of the hardware system. The following items are defined in the model:

(1) 2075J Processor with:

    (a) One megabyte of main memory.

    (b) Two megabytes of large capacity storage.

(2) 2870-1 Multiplexer channel with

    (a) 2821-5 control unit with on-line devices.

    (b) 2848-2 display controls with 2260 cathode ray tube devices.

    (c) 2803 tape control with two 7- and two 9-track drives.

    (d) 2403 tape control with two 7- and three 9-track drives.

    (e) Interface with digital TV assembly.

(3) 2860-2 Selector Channel with

    (a) 2314[1] disk file on channel 1.

    (b) 2314[1] disk file on channel 2.

    (c) Storage channel adaptor.

(4) 2909-3 Asynchronous data channel with

    (a) High-speed data input subchannels (6).

    (b) High-speed data output subchannels (4).

    (c) Comm processor input and output subchannels.

    (d) DTV format request unit input subchannel.

    (e) 1443/2501 selector subchannels (3) with seventeen 1443 printers and seven 2501 card readers.

The model defined the functional capabilities of the five SFOF software subsystems as given in Table 1. The statistics gathering system (SGS) that functions under the control of the 360/75 operating system provided timing information from the "live" system that was used to calibrate the model. In addition, data obtained from listings, flow charts and other design information provided a percentage of manual calibration, as given in Table 1.

IV. Environment and Sequence of Events

The runs were made to reflect processing that is expected to occur during the launch phase of the second *Mariner* Mars 1971 spacecraft. The same real-time input was assumed for all runs to provide a common basic activity for purposes of comparison. The first *Mariner* Mars 1971 spacecraft was assumed to have been launched successfully and was in cruise. The mission support system was assumed to have been running prior to the time period simulated.

In addition, *Pioneers 6* through 9 were assumed to be operational. Tracking data from two of these spacecraft were received, processed and displayed by the 360/75.

[1]Model assumes 2314's are 1's.

Table 2 lists the real-time input data streams received at the 360/75 in the SFOF. All data were processed except duplicate engineering streams for the *Mariner* Mars spacecraft.

In addition to the processing of the real-time data shown in Table 2, the command subsystem was exercised to transmit standards and limits and station configuration data. The command subsystem was also used to transmit and enable a command card file using the input messages (MEDs) listed in Table 3.

During the five minutes simulated, telemetry data for the second *Mariner* Mars 1971 spacecraft were being recalled from the system data record (SDR), processed, and displayed on digital TV at a rate of one subframe every 10 sec.

After 2 min of simulated time, the monitor subsystem executed two raw data dumps of six blocks each on the 1443 printer.

Manual input message requests, using the DTV format request boxes, were simulated at the rate of one request per minute.

Table 4 lists the displays that were initialized during each run.

The 2314 disk packs were configured in the model according to the physical assignments made for the *Mariner* Mars 1971 Mission Operations test of March 17, 1971. The contents of the data sets on the disk packs in the model (Table 5) were similar to those in the JPL mission support software system, Model 2, Version 26.3.

V. Modeling Runs

Four minutes of real-time operation were simulated during Run 1 and 5 min during Runs 2 and 3. Statistics were printed after each 1-min SNAP interval.

Run 1 has normal processing of real-time data and the execution of COMGEN in the environment described in Section IV.

Run 2 has same script as for Run 1. The model itself was modified by moving the telemetry subsystem data tables (including the master data record) from the MSA3A2 and MSD3A2 mission disk packs to an empty pack. This pack was assigned in the model to disk drive

231. The objective of this change was to evaluate a possible method of alleviating the disk I/O problem noted in Run 1 and reduce the backlog of in-core, telemetry data blocks.

Run 3 has same script as for Run 1. The model was modified, relative to the Run 1 configuration, by moving all data tables of the near-real-time processors, including COMGEN from the MSA3A2, MSC3A2 and MSD3A2 disk packs to an empty disk pack. This pack was assigned in the model to disk drive 131. The objective of this run was to evaluate a second method of alleviating the disk I/O problem noted in Run 1 and also reduce the backlog of in-core telemetry data blocks.

VI. Results

The results of the three runs are summarized in Tables 6, 7, and 8. Each of the snap intervals represents one minute of simulated real-time.

A. Significant Items

Run 1 results are shown in Table 6. CPU utilization averaged slightly above 40%, leaving 60% of the time available for additional processing. The total amount of main memory available, with purging, varied between 134,000 and 174,000 bytes, while between 251,000 and 268,000 bytes of large capacity storage (LCS) were available. Disk drive 137 (MSD3A2) was heavily used. Excessively long delays for I/O caused ever increasing backlogs of telemetry input data because the telemetry processor required many data table accesses. Core lockout would soon occur.

Run 2 results are shown in Table 7. More was accomplished by COMGEN during this run than during Run 1. In Run 1, execution of the editor function was not completed. In Run 2, execution of the editor function was completed and the simulator function began execution. Had the newly created disk pack been placed on channel 1 of the 2860-2, rather than channel 2, a slightly better performance might have been realized.

CPU utilization increased due to the greater execution of COMGEN. However, during the last four minutes of the run, approximately 54% of the time the CPU was available for additional processing.

The total amount of main memory available, with purging, varied between 160,000 and 198,000 bytes, while between 131,000 and 268,000 bytes of LCS were available.

Task response times for the telemetry subsystem improved by a factor of better than 2:1. In addition, there was no backlog of in-core, telemetry data blocks.

Run 3 results are shown in Table 8. Slightly better performance by COMGEN, based on the increased number of data table accesses, was noted in comparison to the results achieved in Run 2.

CPU utilization increased slightly over the entire run. During the last four minutes of the run, approximately 50% of the time the CPU was available for additional processing.

The total amount of main memory available, with purging, varied between 148,000 and 194,000 bytes, while the amount of LCS available was the same as for Run 2.

Task response times for the telemetry subsystem improved slightly over Run 2. There was no backlog of in-core telemetry data blocks during Run 3.

VII. Conclusions

As shown in the results from Run 1, problems can arise when attempting to operate under a normal situation. Runs 2 and 3 were made to evaluate possible means of alleviating the problem. Either of these alternate data table allocations were shown to improve system performance and prevent data backlog because of heavy disk I/O:

(1) Move all telemetry data tables to an unused disk pack.

(2) Move all data tables used by near-real-time processors to an unused disk pack.

With the addition of more processing and the running of Mission Operation System (MOS), near-real-time programs during the orbital phase of the *Mariner* Mars 1971 mission, additional system problems may be encountered. Heavy usage of main core, LCS and disk I/O activity occurred during the launch phase simulation runs. Increased usage of these resources can be expected during the heavy activity, orbital phase.

VIII. Future Modeling Activities

The present version of the SFOF Mark IIIA model is being expanded to include those capabilities that will be implemented to support the orbital phase of the *Mariner* Mars 1971 dual spacecraft mission.

A series of runs will be made with the model subjected to loading conditions that will occur during the orbital phase.

Based upon the results of these runs, recommendations that could improve system performance and overall operating efficiency will be made.

Reference

1. Simon, H. S., "SFOF Mark IIIA Central Processing System Model Development," in *The Deep Space Network*, Technical Report 32-1526, Vol. I, pp. 95–102. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1971.

Erratum

Referring to "SFOF Mark IIIA Central Processing System Model Development" by H. S. Simon in Technical Report 32-1526, Vol. I, Feb. 15, 1971, on p. 97; Table 1, col. 1, entry 5 should read "Supervisor/MVT service, %" instead of "Supervisor/mission and test video service, %."

Table 1. Software subsystem capabilities modeled with calibration data

Subsystem	Calibration data, % of capability	
	SGS	Manual
1. Master control (MC)		
Main storage management	100	100
Large capacity storage (LCS) management	10	100
Routing	100	100
Task management	100	100
Contents control (with purge)	100	100
Data table access method	100	100
I/O control	40	100
Real-time access methods (RTAM)	90	100
Logging	100	100
JPL Mods to Houston's real-time operating system (RTOS)		
Data accountability system (DAS)	10	100
Master data record access method (MDRAM)	100	100
Real-time access of tape (RTTAPE)	80	100
Card subroutine (RTCARD)	0	100
Fortran RTAM	100	100
Fortran I/O (real-time)	100	100
2. User interface (UI)		
Formatted output	35	100
Unformatted output	90	100
2260 User station input	90	100
Comm processor and high-speed data output	30	100
3. Tracking data subsystem		
Input processor (TYDIP)	70	75
Output processor (TYDOP)	100	75
Pseudo residuals	0	75
Master file program (MFP)	80	75
4. Telemetry data subsystem		
Mariner Mars 1971 engineering telemetry processor	100	50
5. Command data subsystem		
Command transmission and verification	75	100
6. Monitor and operations control data subsystem		
Accumulation and display of DSIF, GCF, and SFOF data	70	90
Transmission of tracking predicts	10	25
Transmission of DSN sequence of events	10	25
7. Near-real-time processors[a]		
Tracking predicts generator	50	75
COMGEN	10	25
Sequence of events generator	0	0

[a]Operate under the real-time job step.

Table 2. Input data streams

Input data	Via	Rate	Spacecraft	Station
Engineering telemetry	HSDL	33⅓ bps	Mariner '71A	1
Engineering telemetry	HSDL	33⅓ bps	Mariner '71B	2
Engineering telemetry	HSDL	33⅓ bps	Mariner '71B	4
Tracking	CP	1 sample/10 sec	Mariner '71A	1
Tracking	CP	1 sample/10 sec	Mariner '71B	2
Tracking	CP	1 sample/min	Mariner '71B	4
Tracking	CP	1 sample/min	Pioneer	5
Tracking	CP	1 sample/min	Pioneer	6
DSN performance/status	HSDL	1 block /5 sec		1
DSN performance/status	HSDL	1 block /5 sec		2
DSN performance/status	HSDL	1 block /5 sec		4
DSN summary	HSDL	1 block/30 sec		1
DSN summary	HSDL	1 block/30 sec		2
DSN summary	HSDL	1 block/30 sec		4
GCF monitor block	CP	1 block/20 sec		

HSDL = High-speed data line.

CP = Communications processor.

Table 3. Input messages (MEDs) used to transmit command card file

MED	Function
C02	Connect to command
C03	Set up HSD block header
C10	Connect to card file
C11	Start sending out file
C17	Enable block just sent out
C12	Send next block

Table 4. Initialized displays

Subsystem	Display device	Number of displays active
Command	DTV	6 Channels
Tracking	DTV	2 Channels
	1443	4 Devices
	TTY	1 For each station (404)
	TTY	1 For alarms (490)
Telemetry	DTV	32 Channels
	TTY	22 Devices
	1443	8 Devices
Monitor and operations control	DTV	20 Channels

DTV = digital TV.

TTY = printer driven by the comm processor using data received from the 360/75.

Table 5. Contents of data sets on disk packs

Disk pack	Contents	2314 Disk drive
RTOS A	System functions	130
MSB3A2	Mission data sets	133
MSD3A2	Mission data sets	137
MSA3A2	Mission data sets	230
MSC3A2	Mission data sets	236

Table 6. Statistics from Run 1. Real-time processing and COMGEN execution

	SNAP1	SNAP2	SNAP3	SNAP4
CPU utilization	40%	38%	42%	41%
Applications	19%	18%	19%	18%
Operating system overhead	21%	20%	23%	22%
I/O Utilization				
Channel 1	18%	17%	17%	18%
Disk drive 137	84%	86%	85%	87%
Disk drive 230	28%	19%	22%	20%
Seek time				
Disk drive 137	70 ms	79 ms	76 ms	76 ms
Disk drive 230	23 ms	19 ms	21 ms	19 ms
Main core usage				
Available without purge	16K	4K	2K	0K
Available with purge	174K	170K	146K	134K
Number of purges	9	14	14	24
Large capacity storage (LCS) used	1780K	1780K	1795K	1797K
Task queues				
Master data record write				
Number	11	10	13	11
Average time	379 ms	501 ms	398 ms	427 ms
Data table I/O				
Number	911	826	841	853
Average time	126 ms	139 ms	134 ms	138 ms
Data table availability				
Number	31	34	31	30
Average time	296 ms	266 ms	295 ms	217 ms
Real-time I/O				
Number	52	50	55	58
Average time	34 ms	18 ms	139 ms	52 ms
Core				
Number	0	0	0	4
Average time	—	—	—	107 ms
Digital TV (DTV)				
DTV operating system core buffers used (of 30 available)	23	21	22	22
Task response times				
Tracking subsystem	332 ms	311 ms	280 ms	329 ms
Telemetry subsystem	1686 ms	1811 ms	1906 ms	1882 ms
M&OC subsystem	196 ms	159 ms	195 ms	204 ms
Command transmission response time	—	—	337 ms	930 ms
Backlogged telemetry Input data block	9	17	23	29

K = 1000 8-bit bytes.

Table 7. Statistics from Run 2.
Real-time processing and COMGEN execution

	SNAP1	SNAP2	SNAP3	SNAP4	SNAP5
CPU utilization	57%	45%	47%	45%	46%
Applications	27%	20%	20%	19%	19%
Operating system overhead	29%	24%	27%	26%	26%
I/O Utilization					
Channel 1	39%	11%	2%	2%	1%
Disk drive 137	45%	14%	2%	3%	2%
Channel 2	30%	42%	42%	43%	43%
Disk drive 230	17%	54%	70%	69%	68%
Disk drive 231	48%	46%	48%	48%	48%
Seek time					
Disk drive 137	2 ms	4 ms	15 ms	16 ms	21 ms
Disk drive 230	18 ms	19 ms	24 ms	22 ms	22 ms
Disk drive 231	43 ms	45 ms	45 ms	46 ms	45 ms
Main core usage					
Available without purge	20K	12K	30K	6K	6K
Available with purge	198K	190K	164K	160K	170K
Number of purges	11	10	15	16	20
Large capacity storage (LCS)					
used	1780K	1898K	1913K	1915K	1917K
Task queues					
Master data record write					
Number	11	10	9	7	10
Average time	251 ms	182 ms	98 ms	110 ms	96 ms
Data table I/O					
Number	2183	1629	1496	1553	1552
Average time	34 ms	62 ms	79 ms	75 ms	73 ms
Data table availability					
Number	19	26	22	16	17
Average time	95 ms	219 ms	150 ms	183 ms	171 ms
Real-time I/O					
Number	41	52	51	56	53
Average time	17 ms	50 ms	206 ms	66 ms	46 ms
Core					
Number	0	0	0	0	0
Average time	—	—	—	—	—
Digital TV (DTV)					
DTV operating system core buffers used (30 available)	23	23	23	21	22
Task response times					
Tracking subsystem	262 ms	506 ms	617 ms	579 ms	603 ms
Telemetry subsystem	613 ms	814 ms	898 ms	793 ms	875 ms
M&OC subsystem	189 ms	242 ms	279 ms	264 ms	236 ms
Command transmission response time	—	—	250 ms	1154 ms	815 ms

Table 8. Statistics from Run 3.
Real-time processing and COMGEN execution

	SNAP1	SNAP2	SNAP3	SNAP4	SNAP5
CPU Utilization	57%	49%	51%	50%	50%
Applications	26%	21%	21%	20%	21%
Operating system overhead	30%	28%	30%	29%	29%
I/O Utilization					
Channel 1	48%	56%	60%	62%	60%
Disk drive 131	36%	44%	48%	49%	47%
Disk drive 137	31%	30%	32%	30%	31%
Channel 2	18%	18%	11%	11%	10%
Disk drive 230	33%	25%	27%	21%	21%
Seek time					
Disk drive 131	0 ms	0 ms	0 ms	0 ms	0 ms
Disk drive 137	29 ms	29 ms	32 ms	29 ms	31 ms
Disk drive 230	26 ms	14 ms	27 ms	18 ms	20 ms
Main core usage					
Available without purge	12K	16K	12K	6K	20K
Available with purge	176K	194K	182K	148K	168K
Number of purges	10	6	14	19	16
Large capacity storage (LCS)					
used	1780K	1898K	1913K	1915K	1917K
Task queues					
Master data record write					
Number	9	10	9	10	10
Average time	213 ms	224 ms	208 ms	225 ms	182 ms
Data table I/O					
Number	2090	2467	2649	2714	2624
Average time	36 ms	32 ms	30 ms	27 ms	28 ms
Data table availability					
Number	18	23	25	27	24
Average time	97 ms	136 ms	72 ms	116 ms	108 ms
Real-time I/O					
Number	42	51	55	46	47
Average time	18 ms	49 ms	345 ms	112 ms	81 ms
Core					
Number	0	0	0	0	0
Average time	—	—	—	—	—
Digital TV (DTV)					
DTV operating system core buffers used (30 available)	24	25	23	26	26
Task response times					
Tracking subsystem	345 ms	261 ms	334 ms	217 ms	218 ms
Telemetry subsystem	562 ms	558 ms	609 ms	595 ms	605 ms
M&OC subsystem	198 ms	176 ms	196 ms	250 ms	194 ms
Command transmission response time	—	—	278 ms	608 ms	449 ms

See Table 9 for a definition of terms.

Table 9. Definition of terms used in summary results of Tables 6, 7, and 8

CPU Utilization	Percentage of the snap time the 360/75 CPU was in use, i.e., not idle or waiting.
Applications	Percentage of the snap time the CPU was in use by a user program.
Operating system overhead	Percentage of the snap time the processor was in use by the operating system servicing user requests, or interrupts.
I/O Utilization	
Channel utilization	Percentage of the snap time the channel was busy. For the disk channels, the channel is not made busy by seek operations.
Device utilization	Percentage of the snap time the device was busy.
Main core	
Available without purge	The minimum amount of core not allocated during the snap interval. This value may be increased by a successful purge.
Available with purge	The minimum amount of core not allocated plus the amount of core allocated to load modules not in use. This represents the amount of core actually available.
Purges	The number of times during the snap, purge attempts were made to free unused load modules to satisfy a GETMAIN request.
Large capacity storage (LCS) used	The maximum amount of LCS used during the snap.
Task queues	
Number	The total number of times all tasks were placed in a wait state for the reason indicated.
Average time	The average time in milliseconds that tasks were in a wait state for the reason indicated.
Digital TV (DTV)	
DTV operating system core buffers used	Maximum number of core buffers required to be used by the DTV operating system.
Task response times	The average time all tasks in the indicated category require to process a real-time queue element, i.e., from the time the RTQEL is activated to the final EXIT under the task.
Backlog	The number of unprocessed RTQEL's at the end of the snap.
Command transmission response time	Average time from the initiation of the input message request to the transmission of the data block over the outbound high-speed data line.